HVAC: Residential Air Conditioner Sizing

Description

The residential standards do not currently impose limits on the size of air conditioners that can be installed, even though the size has a major impact on peak demand for electricity. This topic area will consider ways to limit air conditioner size.

The initial proposal is that the CEC would adapt industry standard sizing calculations as published in the *ASHRAE Handbook of Fundamentals* to produce an official sizing calculation. This calculation would be made consistent with the parameters used in the ACM Manual for energy calculations and would include the effects of measures required by the prescriptive standards and other measures typically included in California houses. The sizing calculation would include rules for design temperatures, solar intensity, internal gains, window shading, and any other independent values required. Appropriate factors to allow for the incremental sizes of available air conditioning units would be included. For builders complying with the standard using the performance approach, the official calculation would be applied to the proposed design of each house, and the certified compliance software would calculate a maximum-allowed air conditioner size. The maximum size would be stated at rated conditions for comparison with published air conditioner capacities. Compliance would be demonstrated by showing that the total air conditioning capacity installed was less than the maximum allowed. There are a number of issues to be resolved in developing the sizing calculations:

1. California Measures and ACM Calculations. Current industry standard sizing calculations are difficult to use in the California compliance context because they do not include some important measures and because they do not accommodate required efficiency descriptors. For example, distribution efficiency is an important factor in California compliance and duct sealing is a prescriptive requirement for all new homes, but distribution efficiency is not included as a variable in the industry standard sizing calculations. Also, windows to be installed in new California homes are required to have SHGC ratings, and low solar gain glass is an important prescriptive requirement in cooling zones, but industry standard sizing calculations are based on defined glazing types which are not consistent with SHGC and do not include low solar gain glass. The industry standard sizing calculation will be adapted to include these and other compliance variables as inputs and to operate smoothly as part of the ACM Manual-defined performance calculation.
2. Design Data. Energy compliance is calculated based on the 16 climate zones, each of which has a standard weather file. Air conditioning sizing will need to respond to the differences in design conditions within the climate zones. However, this would mean that there is potentially a different sizing compliance requirement in each area within a climate zone.
3. Orientation. Compliance calculations for production houses are currently done with the house rotated to each of the four cardinal orientations. If the house design complies in each of the four orientations, it is deemed to comply in any orientation. If the same approach is applied to sizing, the maximum size would be calculated for four (or perhaps eight) orientations, and the largest-calculated, maximum air conditioner size would become the criteria for that design when built in any orientation. Compliance calculations for custom homes are currently done for the actual orientation of the proposed home and sizing calculations would be done using the same approach.
4. Zonal Systems and Attached Units. The industry standard sizing calculations use one set of factors for single zone houses with glass on four sides, and a different set of factors for dwelling units or zones that have glass on one or two sides. The second set of factors gives a larger air conditioner size to handle solar loads that occur during only one period, rather than being spread out over the day. The official sizing calculation will have to specify the criteria for when the second set of factors can be used and adjust for incremental capacities when multiple systems are installed in the one building.
5. Multifamily Buildings. Currently, compliance calculations for multifamily buildings are usually done for the building as a whole. Using this strategy, maximum sizing could be calculated on the same basis, adding a factor to account for the incremental sizes of available air conditioners. Compliance would be demonstrated by showing that the sum of the capacities of the air conditioners to be installed was less

than the maximum for the building. Alternatively, sizing could be developed on a unit-by-unit approach that tailors the sizing more closely to the loads for each unit.

6. Prescriptive Sizing Requirements. It may be possible to develop prescriptive maximum air conditioner sizes (Btu/h-ft²) based on climate zone that would allow a builder to demonstrate compliance without doing sizing calculations for the proposed design. This could be consistent with the current package approach to compliance. The prescriptive sizes could be developed using the official sizing method and a version of the prototype house in each climate zone. Treatment of glazing area and orientation is an important issue for the prescriptive size calculations.
7. Sizing Tradeoffs. It may be possible to accommodate those who want to install larger air conditioner capacities by using a tradeoff approach that would provide larger cooling capacity for the same kW demand. For this calculation, maximum air conditioner capacity would be converted to electrical demand kW for the air conditioning system at design conditions for minimum efficiency standard air conditioning equipment. Demand kW for the proposed building would be calculated using the same approach, allowing credit for such measures as higher on peak air conditioner EER, more efficient distribution fans, and lower static pressure in the duct system. Credit could also be allowed for installation of photovoltaic panels. Compliance would be based on showing that the net on peak demand for the proposed system is less than the demand of the maximum size standard system. Post-construction verification, perhaps including measurement of actual air conditioning system demand by a HERS rater using the house electrical meter, may be required for this approach.

Benefits

The primary benefit would be a reduction in the peak electrical demand imposed by new homes on the state's electricity supply. Data from field surveys indicates that installed air conditioners are typically larger than actually needed to meet the design load. Air conditioners operating on peak in California's hot central valley climates typically draw 1.7 kW/ton of rated capacity or more.

In addition, correctly-sized air conditioners will provide better latent load capability and increased comfort for homebuyers. Oversizing causes excess cycling, which reduces the ability to remove latent loads and makes the occupant less comfortable due to high indoor relative humidity. This situation leads to callbacks for contractors who often try making the unit bigger, thereby exacerbating the problem.

One secondary effect of sizing rules would be that building a better envelope, from a cooling load point of view (low solar gain glass, shading, cool roof, better insulation,) would result in a reduction in the allowable air conditioner size compared to providing energy compliance with other measures, such as higher AC SEER, or high efficiency heating or water heating equipment. If builders and buyers perceive a small air conditioner to be less desirable, sizing rules might become a disincentive for good envelope measures.

Environmental Impact

The positive environmental impact will result from less on peak electricity production by low efficiency peaking plants, and a reduced need for new generating capacity.

Type of Change

A requirement for residential air conditioner sizing would expand the scope of the *Standards* to require compliance with a new set of rules in addition to the current types of energy efficiency standards requirements. The change would attempt to reduce air conditioner oversizing in buildings meeting the energy standards, but it would not add new building efficiency measures.

This change will require modification of all of the Standards documents (*Standards,* ACM, Manuals, compliance forms, etc.). A new requirement for maximum air conditioner size will be added to the *Standards*. A new section will be added to the ACM Manual to define the calculation for air conditioner size. New ACM tests will be defined to verify sizing calculations. A new section will be added to the Residential Manual to explain the sizing requirement and the details of the calculations. Modifications to the compliance forms will be needed to document the size of the air conditioner and allow field verification.

Measure Availability and Cost

Air conditioner sizing calculations are available in guideline form from a variety of organizations including ASHRAE and ACCA. A number of computer implementations are available and in use in the residential HVAC industry. It is expected that sizing would be integrated into the performance method certified programs and would add very little time and effort to the calculation. Basic compliance would be relatively simple and inexpensive. Field verification, if required, would add to the cost.

Useful Life, Persistence and Maintenance

The peak demand savings provided by a smaller capacity system are very reliable and will persist as long as the system. A potential persistence issue occurs if split system outdoor units are replaced with larger capacity units after final inspection.

Performance Verification

For the standard sizing calculation approach, verification consists of simply comparing the rated capacity of the installed air conditioning units with the maximum allowed prescriptive size, or the size calculated for the building and printed on the compliance forms.

The tradeoff procedure, based on peak system kW demand, needs to be verified by a field measurement. The field measurement procedure needs to be developed and documented, including an approach allowing it to be performed at other-than-peak conditions.

Cost Effectiveness

The cost of the added sizing calculations can be compared to the value of reduced peak demand. The reduced capital cost of the smaller air conditioning system can be included. Using this approach, it is expected that sizing limits will be very cost effective.

Analysis Tools

The current Residential ACM does not calculate demand (TDV versions would add this capability). However, sizing and its benefits need be calculated separate from energy analysis, using a design conditions-oriented procedure. Commercially-available sizing software, with relatively minor modifications, should be able to duplicate the new California sizing calculation. Some certified compliance programs, Micropas for example, currently offer sizing calculations which will be adaptable to the new calculations.

Relationship to Other Measures

Sizing calculations would support the TDV analysis, which will implement models where size is an issue.

Bibliography and Other Research

2001 Handbook of Fundamentals, pages 28.1-28.6, ASHRAE, Atlanta, GA.